# PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2001-170788

(43)Date of publication of application : 26.06.2001

(51)Int.CI. B23K 26/06

G02F 1/37

H01S 3/00

H01S 3/109

// B23K101:42

(21)Application number : 11-352384

(22)Date of filing : 10.12.1999

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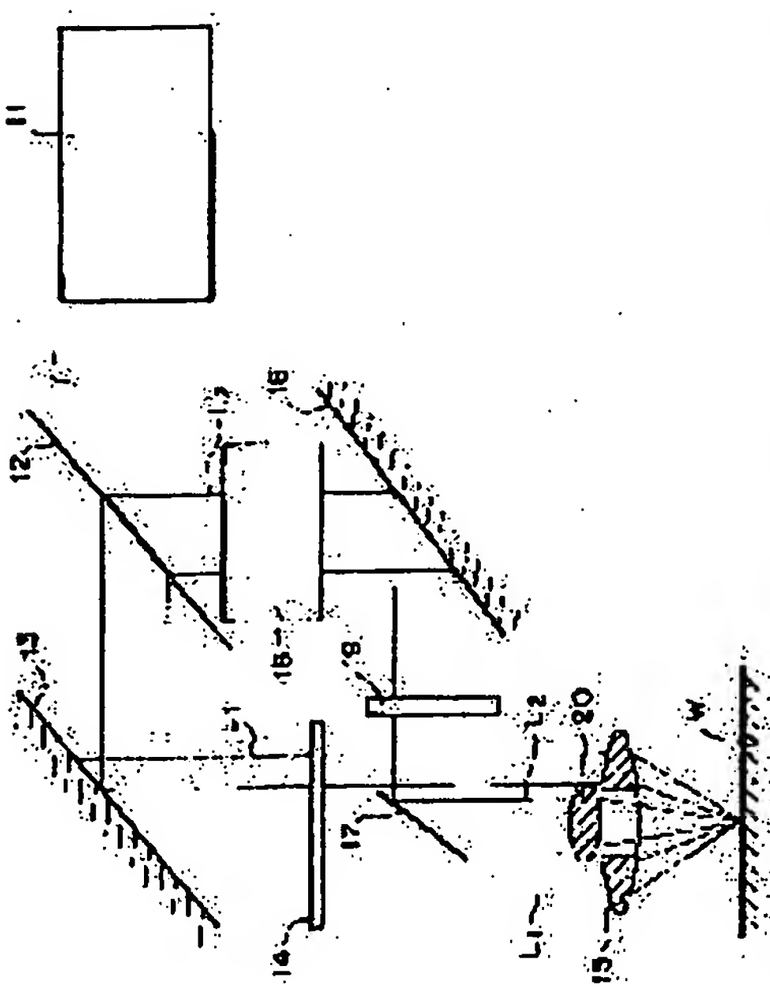
## (54) METHOD OF LASER MACHINING AND DEVICE THERFOR



(57)Abstract:

PROBLEM TO BE SOLVED: To solve a problem that two kinds of laser beam sources are necessary to oscillate two kinds of laser beams having different wavelengths, the expenses for an investment in equipment increase, a larger space for installation is required and the equipment is hardly made compact.

SOLUTION: The device is provided with a laser beam source 11 which oscillated a single laser beam L, a beam splitter 12 which splits the laser beam L oscillated by the laser beam source 11 into two laser beams L1 and L2, a first converging optical system 14 which directly converges one laser beams L1 onto the worked surface of a work W, a non-linear optical system 18 which converts the wavelength of the other laser beam L2, and a second converging optical system 20 which converges the laser beam L2 whose wavelength has been converted by the non-linear optical system 18 onto the worked surface of the work W.

LEGAL STATUS

[Date of request for examination]

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision of rejection]

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[Claim(s)]

[Claim 1] The laser-processing approach characterized by having the step which divides a single laser beam into two, the step which condenses one laser beam to the processing field of a work piece as it is, and the step which carries out wavelength conversion of the laser beam of another side, and condenses to the processing field of said work piece.

[Claim 2] The laser beam of another side is the laser-processing approach according to claim 1 characterized by being the high order higher harmonic of one laser beam.

[Claim 3] The laser-processing approach according to claim 2 characterized by processing a work piece by the laser beam of another side after processing a work piece by one laser beam.

[Claim 4] Said single laser beam is the laser-processing approach according to claim 2 or 3 characterized by being the laser beam of an infrared region.

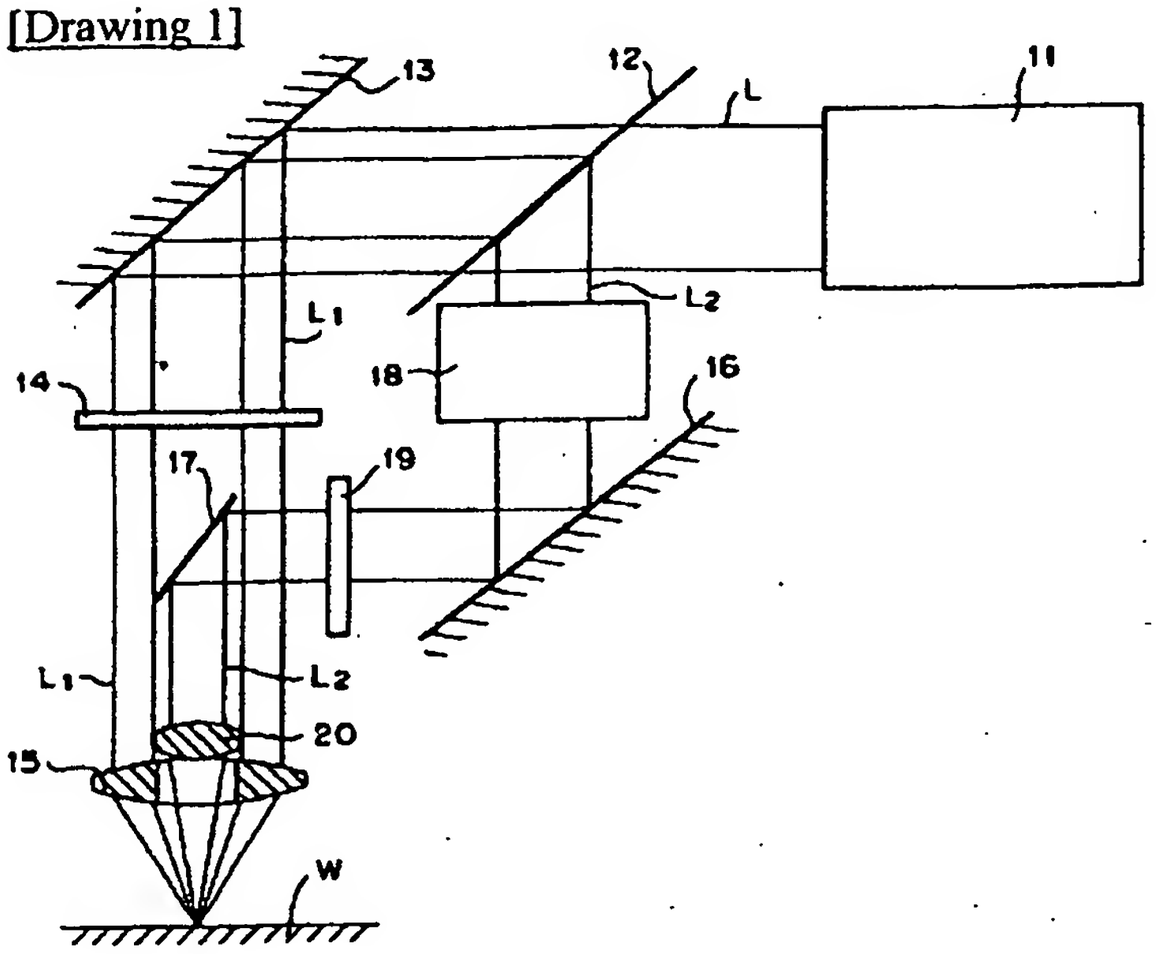
[Claim 5] The laser beam of said another side by which wavelength conversion was carried out is the laser-processing approach according to claim 4 characterized by being the laser beam of a visible region or an ultraviolet region.

[Claim 6] The laser light source which oscillates a single laser beam, and the beam splitter which divides into two laser beams the laser beam oscillated from this laser light source, The 1st condensing optical system which makes the processing side of a work piece turn and condense one laser beam as it is, Laser-processing equipment characterized by having the nonlinear optics system which carries out wavelength conversion of the laser beam of another side, and the 2nd condensing optical system which makes the processing side of said work piece turn and condense the laser beam by which wavelength conversion was carried out by this nonlinear optics system.

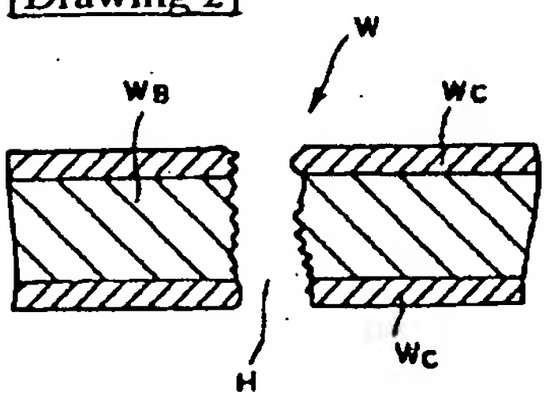
[Claim 7] Said laser light source is laser-processing equipment according to claim 6 characterized by oscillating the laser beam of an infrared region.

[Claim 8] Said nonlinear optics system is laser-processing equipment according to claim 7 characterized by changing the laser beam of an infrared region into the laser beam of a visible region or an ultraviolet region.

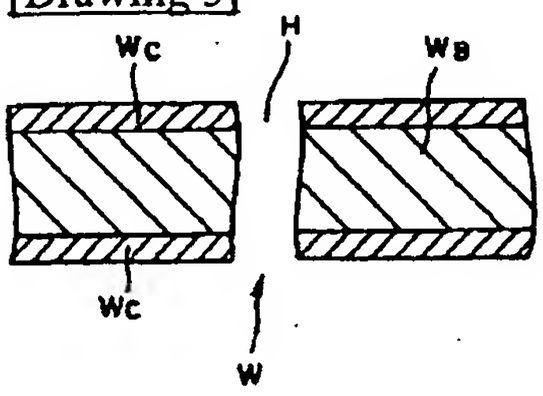
[Drawing 1]




[Drawing 2]




[Drawing 3]




[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the laser-processing equipment which can realize the laser-processing approach for irradiating a laser beam at a work piece and performing removal processing, such as cutting and punching, and this laser-processing approach.

[0002]
[Description of the Prior Art] Laser processing can perform most removal processing to all solid-states in an instant, and is especially effective in an unscrapable material, cutting or minute punching processing of composite material, etc. The YAG laser oscillator the CO2 laser oscillator whose wavelength is 10.6 micrometers, and whose wavelength are 1.06 micrometers as the laser light source used for such laser processing is known, and these have both the thing of a consecutive output, and the thing of a pulse output.
[0003] To process it using the laser beam which is two kinds from which improvement in processing effectiveness, upgrading of a processing side, etc. are planned, and wavelength differs in such laser processing is tried. For example, in metalworking, melting of the front face of a work piece is first carried out to the metal which is a work piece by the short wavelength laser beam of low-power output with a low reflection factor as indicated by JP,62-289390,A. Next, after processing a work piece into a predetermined configuration by the high power long wavelength laser beam or processing a work piece by the high power long wavelength laser beam, it is finish-machining by irradiating a short wavelength laser beam.
[0004]
[Problem(s) to be Solved by the Invention] By the conventional laser-processing approach indicated by JP,62-289390,A The CO2 laser oscillator and YAG laser oscillator which oscillate two kinds, for example, a long wavelength laser beam, corresponding to this when using two kinds of laser beams from which improvement in processing effectiveness, upgrading of a processing side, etc. are planned, and wavelength differs, It is necessary to use the ultraviolet-rays laser oscillation machine which oscillates a short wavelength laser beam, when the costs which the plant-and-equipment investment for it takes increase, it is necessary to also secure the installation tooth space for it, and miniaturization of a facility is difficult.
[0005]
[Objects of the Invention] The purpose of this invention is to offer the laser-processing equipment which can realize the method of performing laser processing using two kinds of laser beams from which wavelength differs from the single laser light source, and this approach.
[0006]
[Means for Solving the Problem] The 1st gestalt of this invention is in the laser-processing approach characterized by having the step which divides a single laser beam into two, the step which condenses one laser beam to the processing field of a work piece as it is, and the step which carries out wavelength conversion of the laser beam of another side, and condenses to the processing field of said work piece.
[0007] According to this invention, predetermined processing is performed, and wavelength conversion of the laser beam of another side is carried out further, it condenses [ one laser beam of the inside divided into two is condensed to the processing field of a work piece as it is, and ] to the processing field of a work piece, and predetermined processing is performed.
[0008] The laser light source which oscillates a laser beam with the 2nd single gestalt of this invention, The beam splitter which divides into two laser beams the laser beam oscillated from this laser light source, The 1st condensing optical system which makes the processing side of a work piece turn and condense one laser beam as it is, It is in the

laser-processing equipment characterized by having the nonlinear optics system which carries out wavelength conversion of the laser beam of another side, and the 2nd condensing optical system which makes the processing side of said work piece turn and condense the laser beam by which wavelength conversion was carried out by this nonlinear optics system.

[0009] According to this invention, while it is divided into those [ two ] by the beam splitter, one laser beam is condensed to the processing side of a work piece according to the 1st condensing optical system and predetermined processing is performed, the single laser beam oscillated from the laser light source carries out wavelength conversion of the laser beam of another side through a nonlinear optics system, condenses this to the processing side of a work piece according to the 2nd condensing optical system, and performs predetermined processing.

[0010]

[Embodiment of the Invention] In the laser-beam-machining approach by the 1st gestalt of this invention, the laser beam of another side may be the high order higher harmonic wave of one laser beam, and after it processes a work piece by one laser beam in this case, it is desirable to process a work piece by the laser beam of another side.

[0011] Moreover, a single laser beam may be a laser beam of an infrared region, and the laser beam of another side by which wavelength conversion was carried out in this case may be a laser beam of a visible region or an ultraviolet region.

[0012] In the laser-beam-machining equipment by the 2nd gestalt of this invention, it is desirable that it is that from which the laser light source may oscillate the laser beam of an infrared region, and a nonlinear optics system changes the laser beam of an infrared region into the laser beam of a visible region or an ultraviolet region in this case.

[0013]

[Example] Although one example of the laser-processing equipment by this invention which can realize the laser-processing approach by this invention is explained to a detail, referring to drawing 1 R> 1 - drawing 3 , this invention is applicable not only to such an example but other techniques which should be included by the concept of this invention indicated by the claim of this specification.

[0014] As shown in drawing 1 showing the concept of the laser-processing equipment in this example, the laser beam L oscillated from here is an YAG laser oscillator with an output [ with the wavelength of the infrared region which is 1.064 micrometers ] of 40W, and the laser light source 11 in this example is changed into the parallel flux of light of a predetermined path according to the collimation optical system which is not illustrated. In the middle of the optical path of this laser beam L, to an optical path, the beam splitter 12 from which the center section became a total reflection side inclines 45 degrees, and is prepared, and this beam splitter 12 carries out total reflection only of the central part of the laser beam L which carried out outgoing radiation from the laser light source 11, and penetrates the remainder as it is.

[0015] To that optical path, behind a beam splitter 12, the total reflection mirror 13 which carries out total reflection of the laser beam L1 of the ring-like cross section which penetrated this beam splitter 12 inclines 45 degrees, and is formed in it. The shutter 14 for furthermore opening and closing the optical path of the laser beam L1 of a ring-like cross section at the point of the total reflection mirror 13, The condenser lens 15 of the shape of a ring for condensing the laser beam L1 of a ring-like cross section which passed this

shutter to printed circuit board W which is a work piece, and making a through hole H (referring to drawing 2 ) form there is arranged.
[0016] Printed circuit board W in this example is the flexible printed circuit plate which coated both sides of the insulating layer WB of 60-micrometer thickness with the copper foil WC of 18-micrometer thickness, the inside of a perpendicular field is held to the optical axis of a condenser lens 15 at the movable X-Y stage which is not illustrated, and a through hole H is formed in a predetermined part.
[0017] The total reflection mirror 16 which inclined 45 degrees to this optical path in the middle of the optical path of the laser beam L2 of the circular cross section which carried out total reflection by said beam splitter 12 is arranged, and the total reflection mirror 16 concerned and the total reflection mirror 17 which has an parallel reflector are further arranged on the optical axis of a condenser lens 15 at the point of this total reflection mirror 16. This total reflection mirror 17 is in the condition of having inclined 45 degrees to the optical path of the laser beam L1 of the ring-like cross section between said shutters 14 and condenser lenses 15, and is set as a dimension which does not interrupt the laser beam L1 of a ring-like cross section. This is infixed in the nonlinear optics system 18 changed into the wavelength of 355 micrometers of the ultraviolet region which is the 3rd higher harmonic in the middle of the optical path of the laser beam L2 of the circular cross section between said beam splitters 12 and total reflection mirrors 16. KDP (potassium dihydrogenphosphate) is used for the nonlinear optics system 18 in this example, it is the thing of the common knowledge as a harmonic generation component to laser light, and, naturally it is also possible to adopt the thing of other common knowledge. moreover, in the middle of the optical path of the laser beam L2 of the circular cross section between two total reflection mirrors 16 and 17 The shutter 19 for opening and closing the optical path of the laser beam L2 of a circular cross section is infixed. The laser beam L2 of the circular cross section which furthermore carried out total reflection to the point of the total reflection mirror 17 in this total reflection mirror 17 is condensed to printed circuit board W. The condenser lens 20 for performing finish-machining of the through hole H formed of the laser beam L1 of a ring-like cross section, as shown in drawing 3 is arranged.
[0018] While positioning printed circuit board W and opening a shutter 14 on the occasion of an actual activity, a shutter 19 is closed, and the through hole H as carried out 30-shot pulse irradiation of the laser beam L1 of a ring-like cross section to the predetermined location of printed circuit board W, for example and shown in drawing 2 is drilled. Subsequently, the switching condition of shutters 14 and 19 was switched and 31-shot pulse irradiation was carried out to the same location as a previous processing location using the laser beam L2 of a circular cross section, for example, as shown in drawing 3 , the irregularity and carbide of a wall of a through hole H were removed, and it finish-machined, and the through hole H whose bore is 100 micrometers was formed.
[0019] Thus, the nonlinear optics system 18 is arranged in the middle of the optical path of the laser beam L1 of a ring-like cross section, a through hole H is formed in the predetermined location of printed circuit board W by the laser beam L2 of a circular cross section, and it may be made to finish-machine by the laser beam L1 of a ring-like cross section, although it was made to finish-machine by the laser beam L2 of a circular cross section the wall of a through hole H in the example a through hole H following this. Moreover, it is also possible to irradiate two laser beams L1 and L2 to a work piece at

coincidence depending on the gestalt of processing to a work piece or a work piece.
[0020]
[Effect of the Invention] According to this invention, by dividing into two, condense one laser beam for a single laser beam to the processing field of a work piece as it is, and 1st processing is performed. Since wavelength conversion of the laser beam of another side is carried out, it condenses to the processing field of a work piece and it was made to perform 2nd processing, it becomes possible for it to become unnecessary to prepare an expensive laser oscillation machine two kinds, and to reduce facility cost and installation tooth spaces, and miniaturization of equipment can be planned.